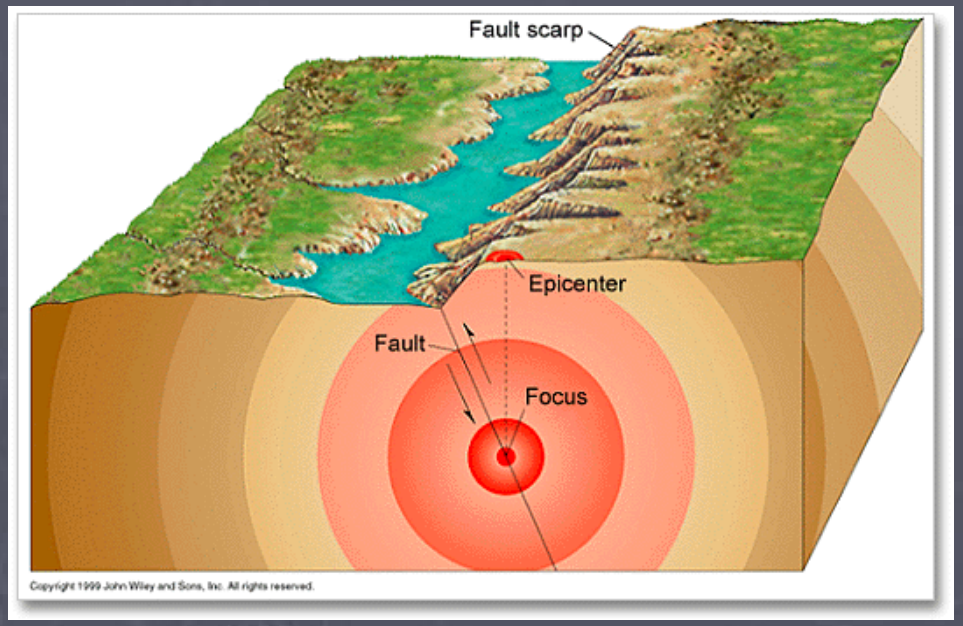
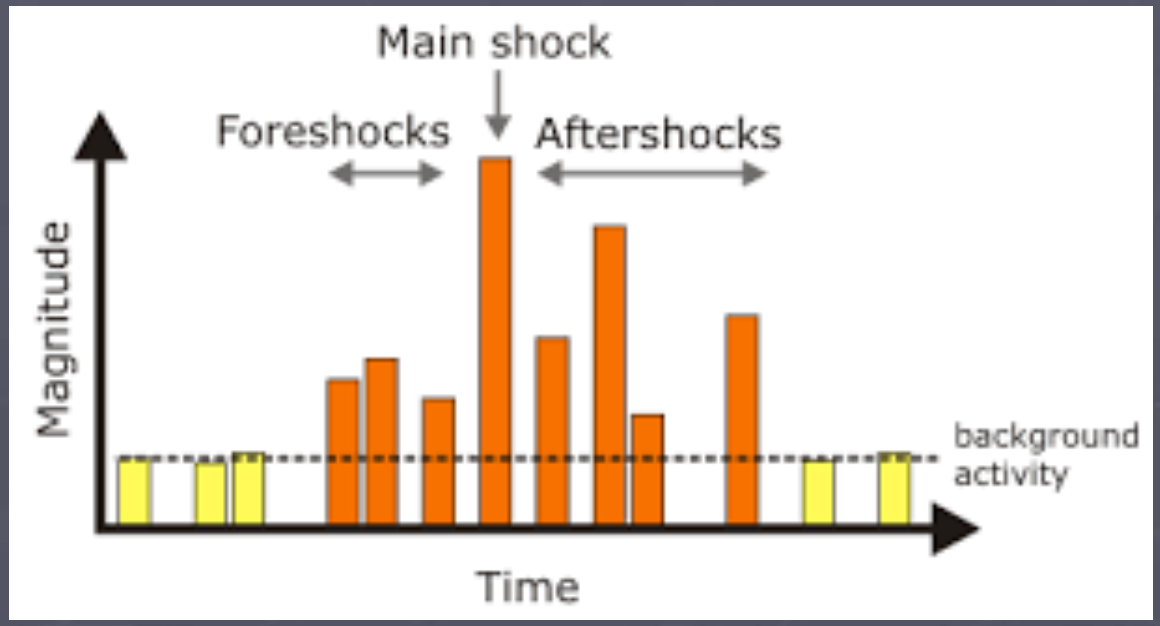
Seismology and Volcanology

Chapter 12: Tectonics, Earthquakes, & Volcanism

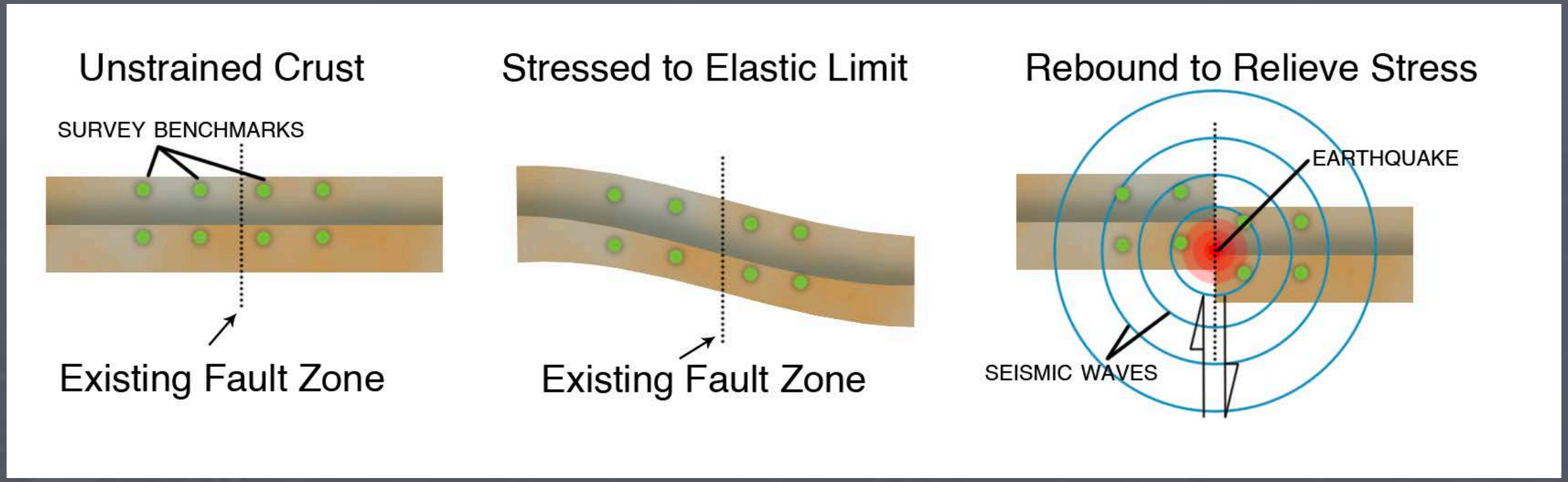
Earthquake Terminology

- **Focus**: Subsurface area along the fault plane where motion is initiated
  - **Epicenter** is the area on the surface directly above the focus
- Foreshocks – smaller shocks that precede main shock
- Aftershock – smaller shocks that occur after main shock





Elastic Rebound Theory



Measuring Earthquakes

- Modified Mercalli Scale
  - Measures intensity of shaking and damage on surface (Primarily used around the world)
- Richter Scale
  - Measures amplitude of largest seismic waves (Primarily used by U.S.)
- Moment Magnitude Scale
  - Measures amount of Energy Released (Used by scientists)

1964 Good Friday Earthquake in Anchorage, Alaska (9.2 on Moment Magnitude & Richter, XI on Mercalli)

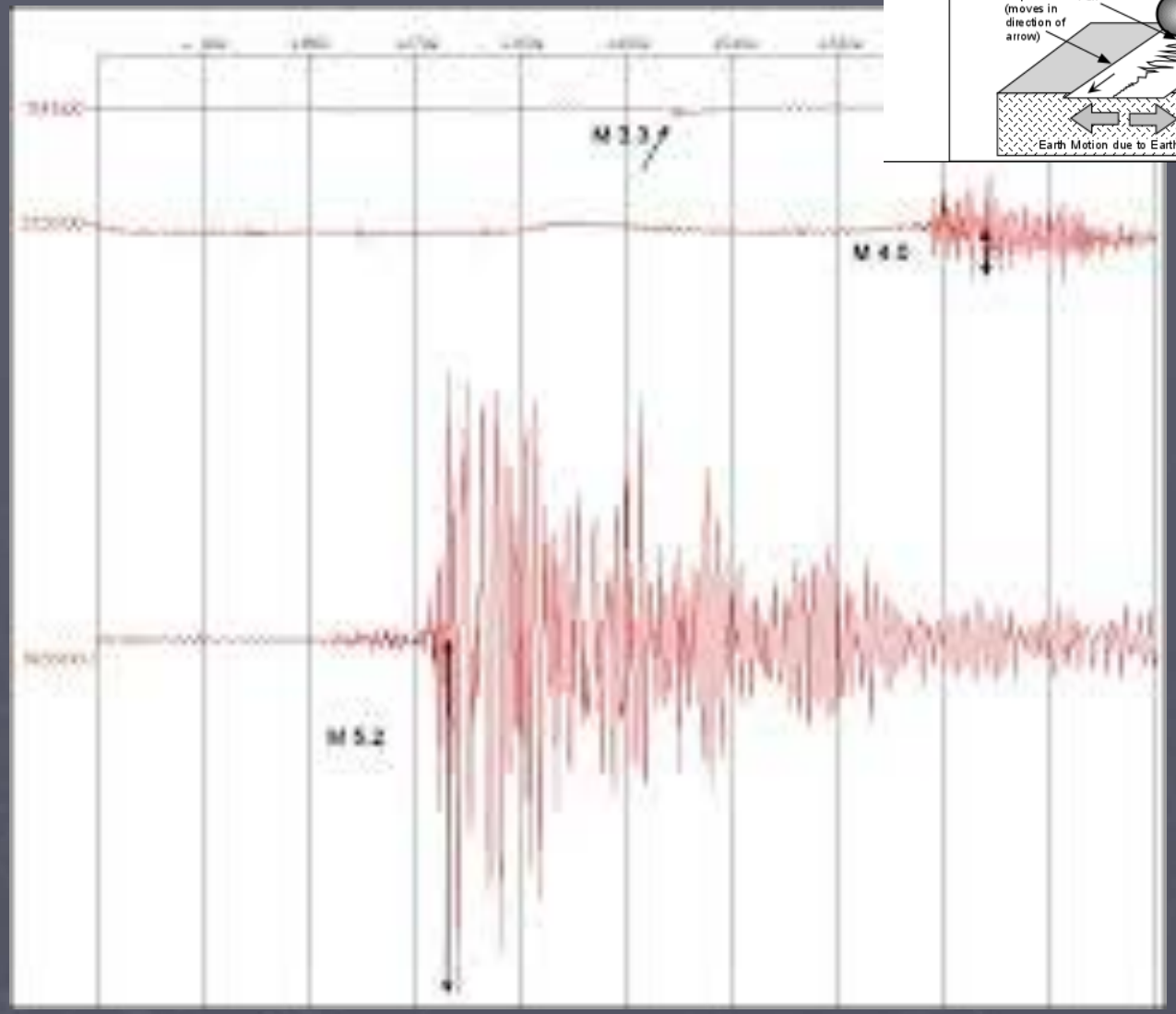
Modified Mercalli Scale

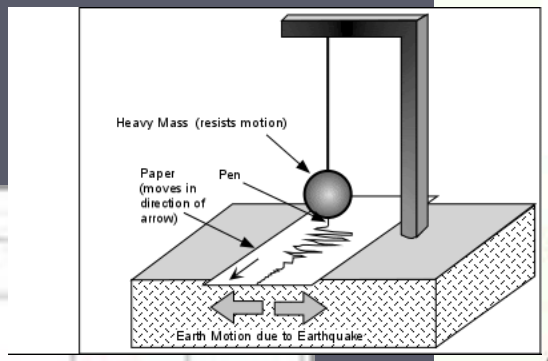
TABLE 12.1 Earthquake Intensity According to the Modified Mercalli Scale

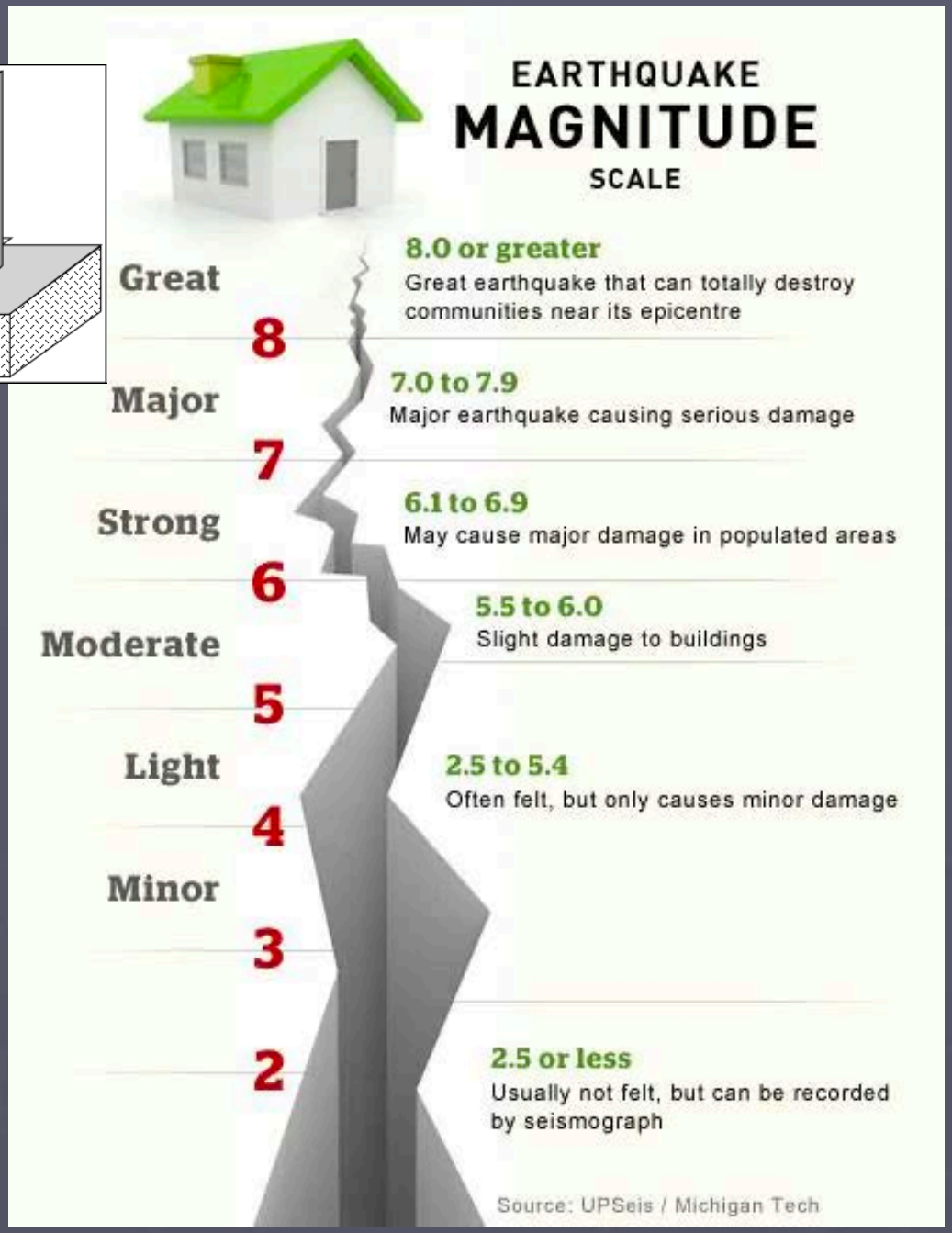
Intensity	Perceived Shaking	Effects on Populated Areas
I	Not felt	Instrumental. Not felt, but recorded.
II–III	Weak	Slight. Felt by some, especially on upper floors of buildings.
IV–V	Light to moderate	Moderate. Felt by some to felt by many; some disturbance and vibration.
VI–VII	Strong to very strong	Strong. Felt by all, with slight building damage.
VIII–IX	Severe to violent	Destructive. Slight to considerable damage, depending on building design; buildings shifted off their foundations.
X–XI	Extreme	Disastrous. Major damage; bridges destroyed, most structures partially collapsed; railroad tracks bent.
XII	Extreme	Catastrophic. Damage nearly total.

Source: USGS Earthquake Hazards Program.

Richter Scale

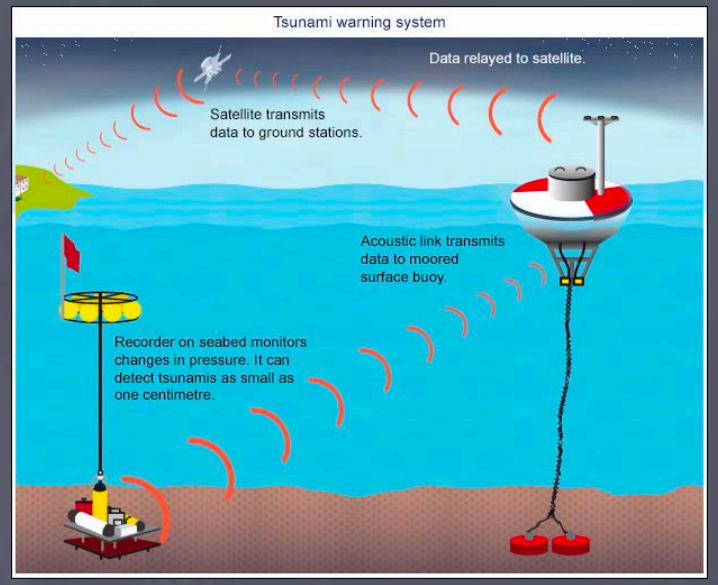


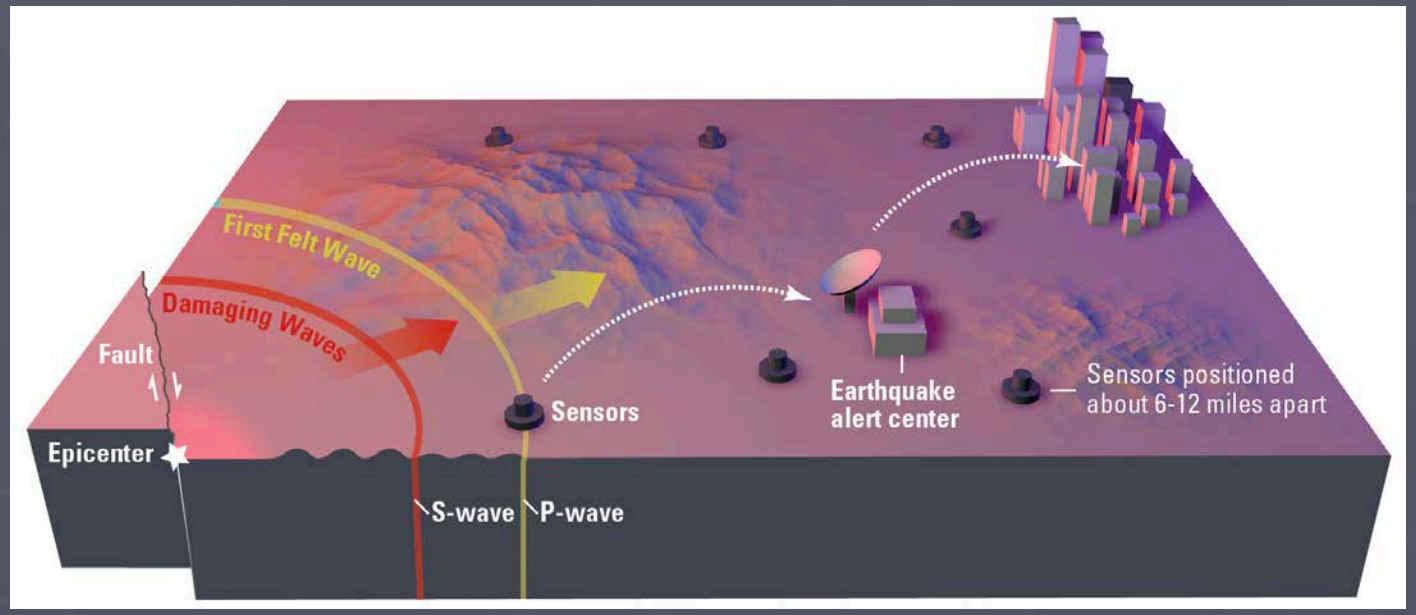




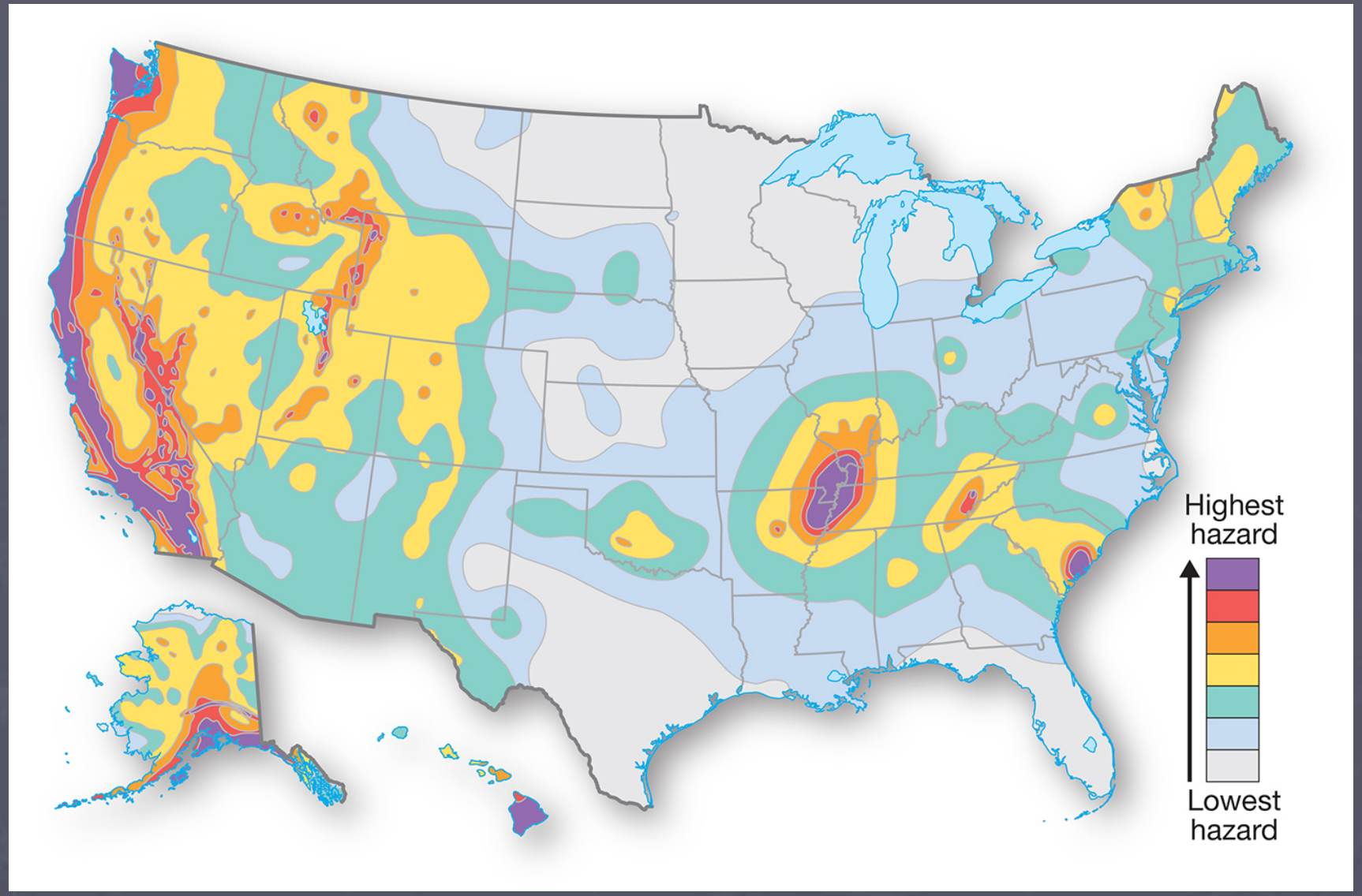
Predicting Earthquakes & Early Warning

- Based on careful monitoring along faults to sense foreshocks
- Calculated based on trends from historical records
- Important in developing disaster awareness plans
  - Especially for coastal regions

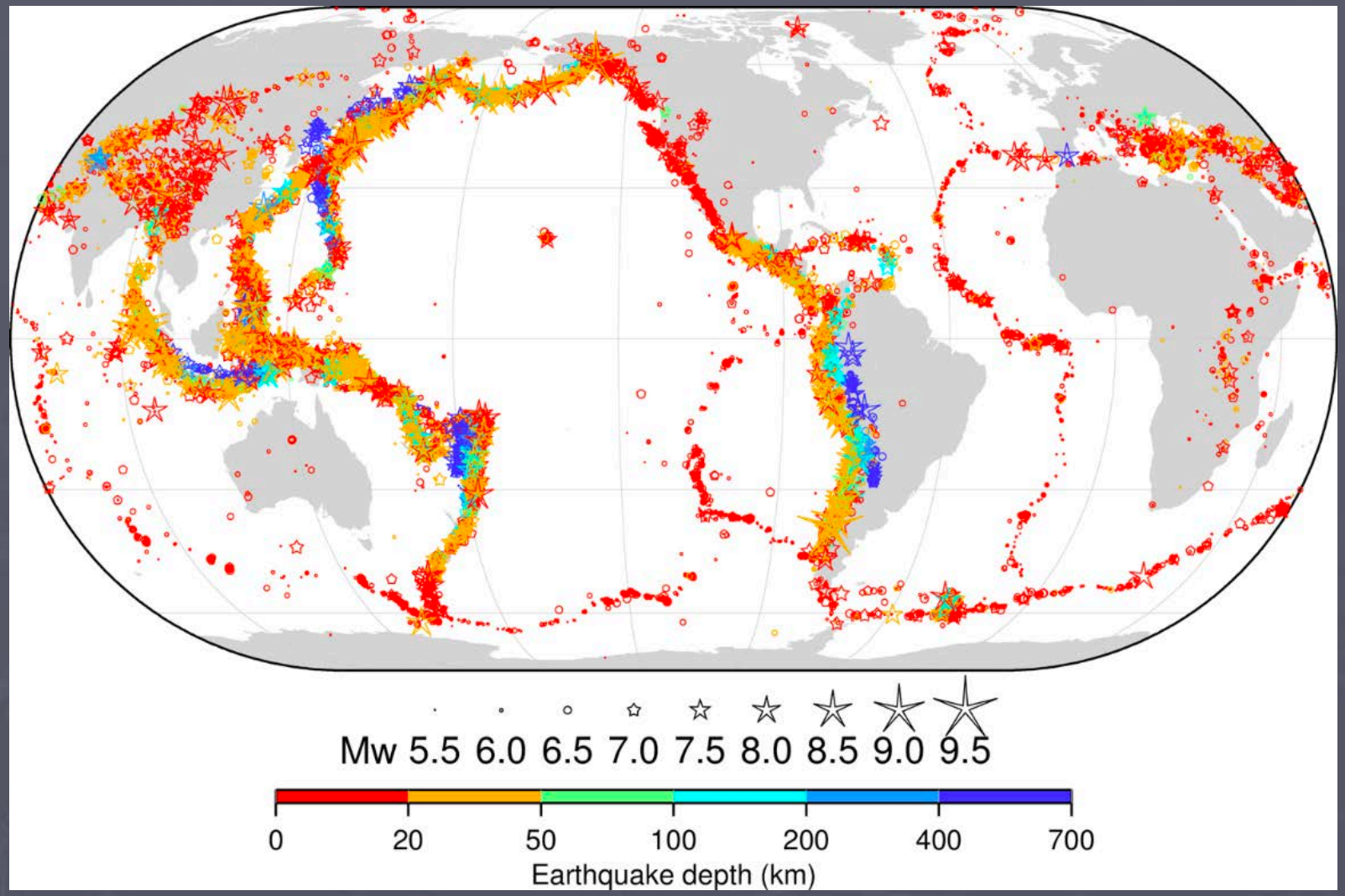




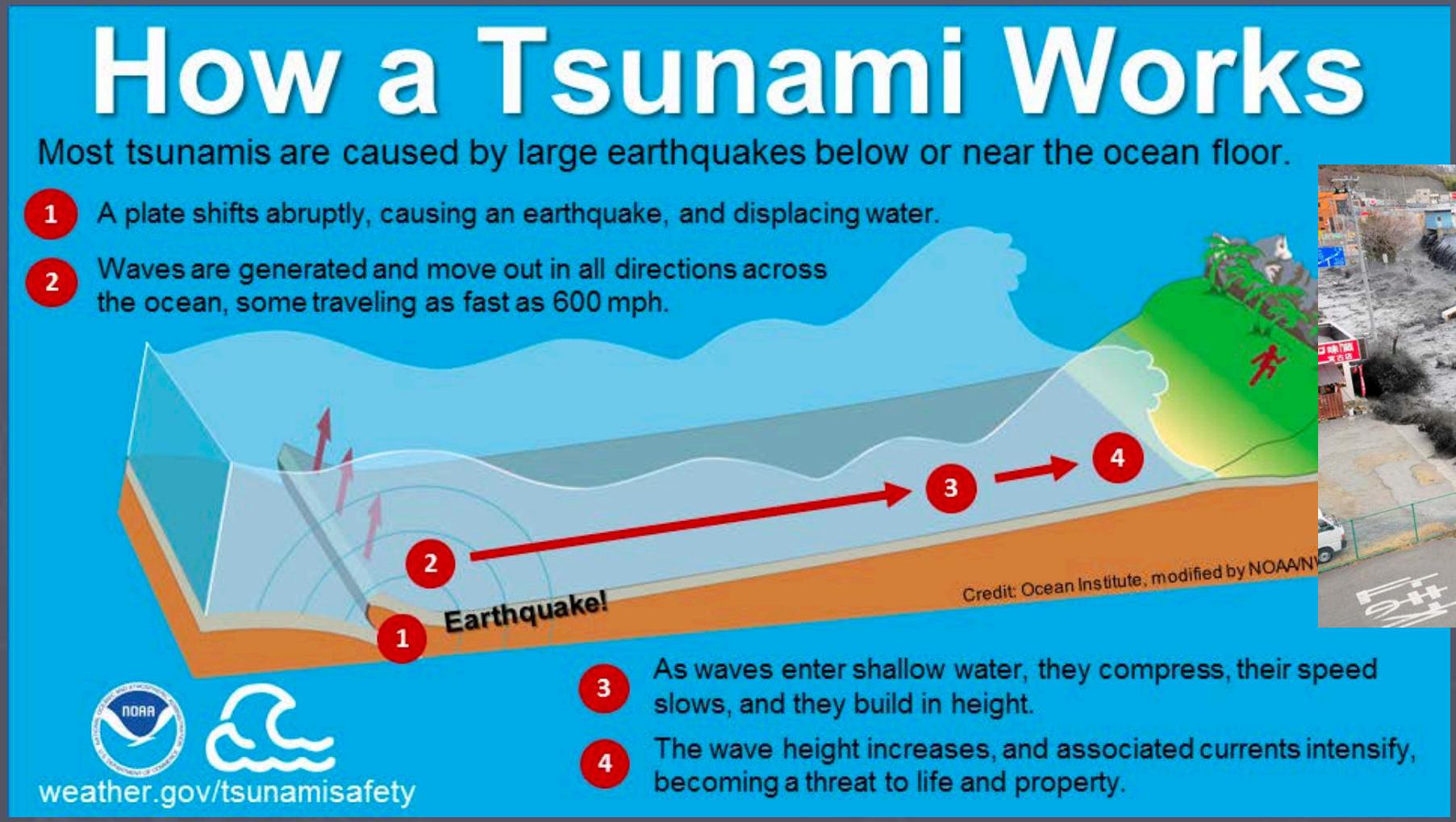
Earthquake Hazard Areas



Global Earthquakes

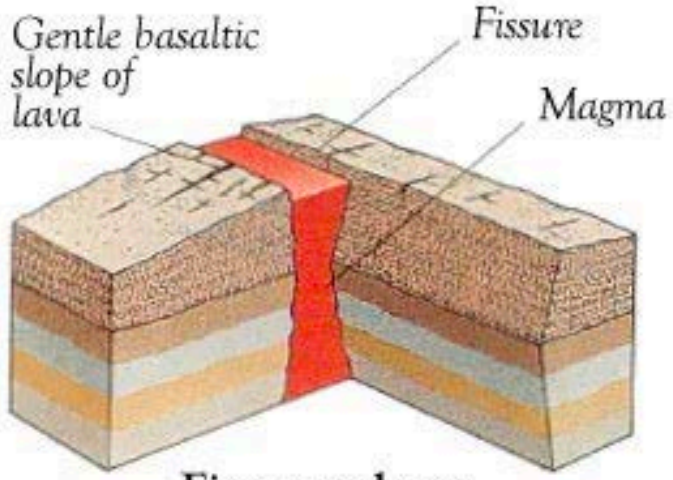


Tsunamis

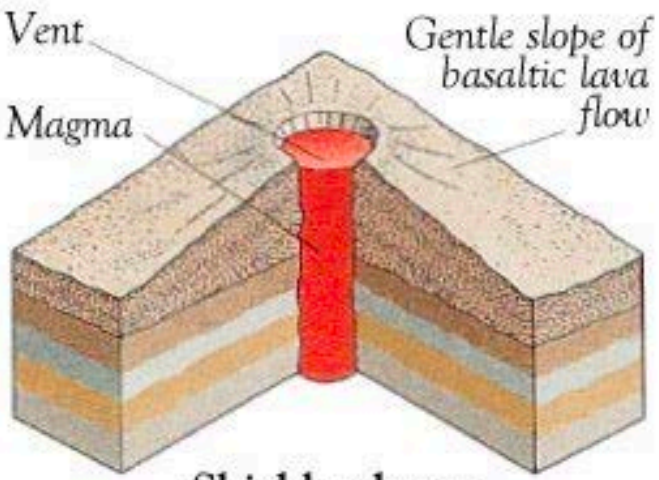

How a Tsunami Works
Most tsunamis are caused by large earthquakes below or near the ocean floor.
1 A plate shifts abruptly, causing an earthquake, and displacing water.
2 Waves are generated and move out in all directions across the ocean, some traveling as fast as 600 mph.
Earthquake!
Credit: Ocean Institute, modified by NOAA/N
3 As waves enter shallow water, they compress, their speed slows, and they build in height.
4 The wave height increases, and associated currents intensify, becoming a threat to life and property.
NOAA
weather.gov/tsunamisafety

Tsunami Predicting

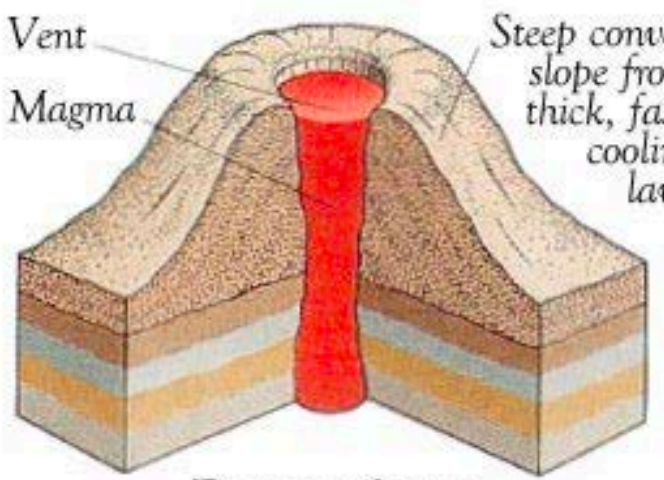
TYPES OF VOLCANO



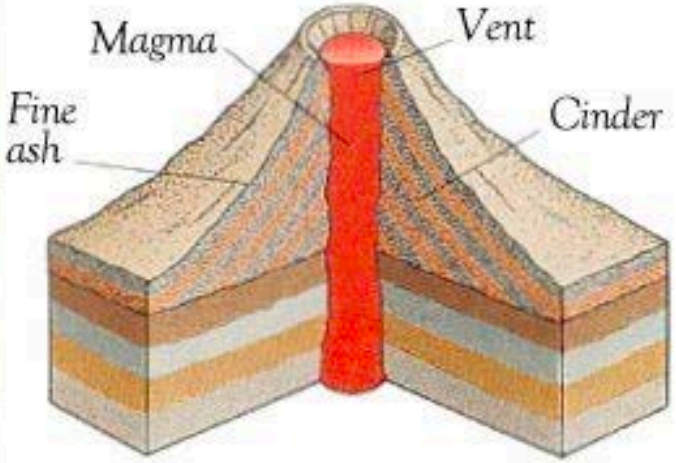
Fissure volcano



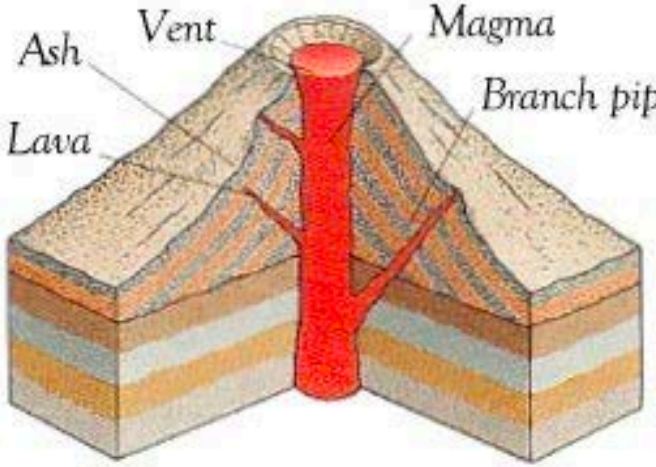
Shield volcano



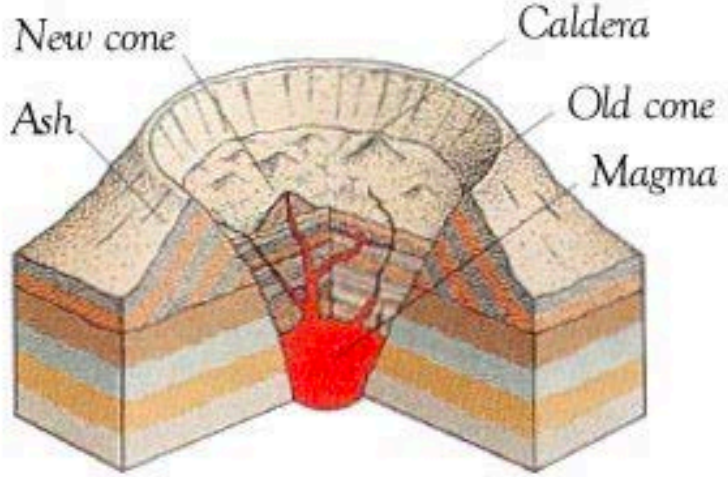
Dome volcano



Ash-cinder volcano

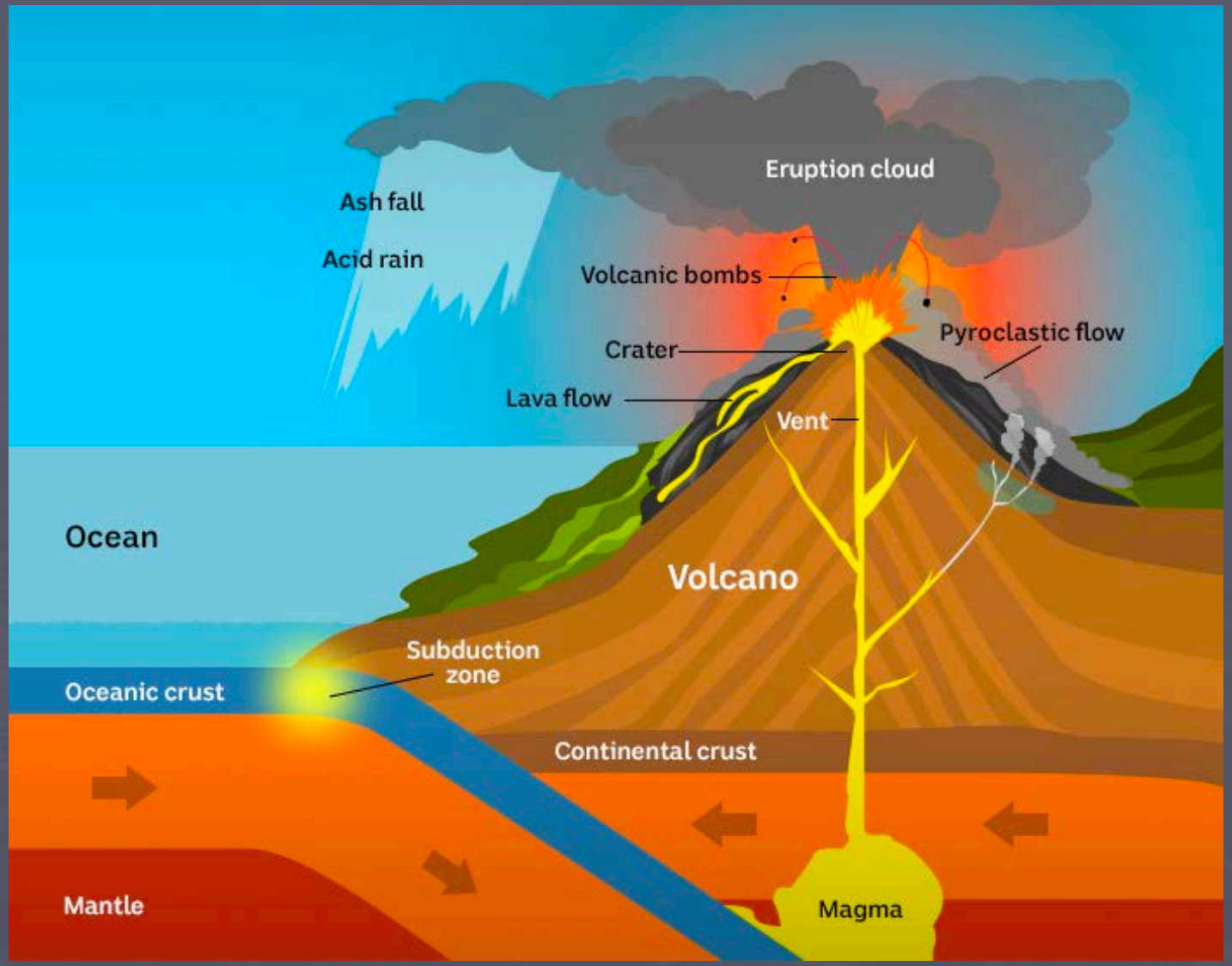


Composite volcano



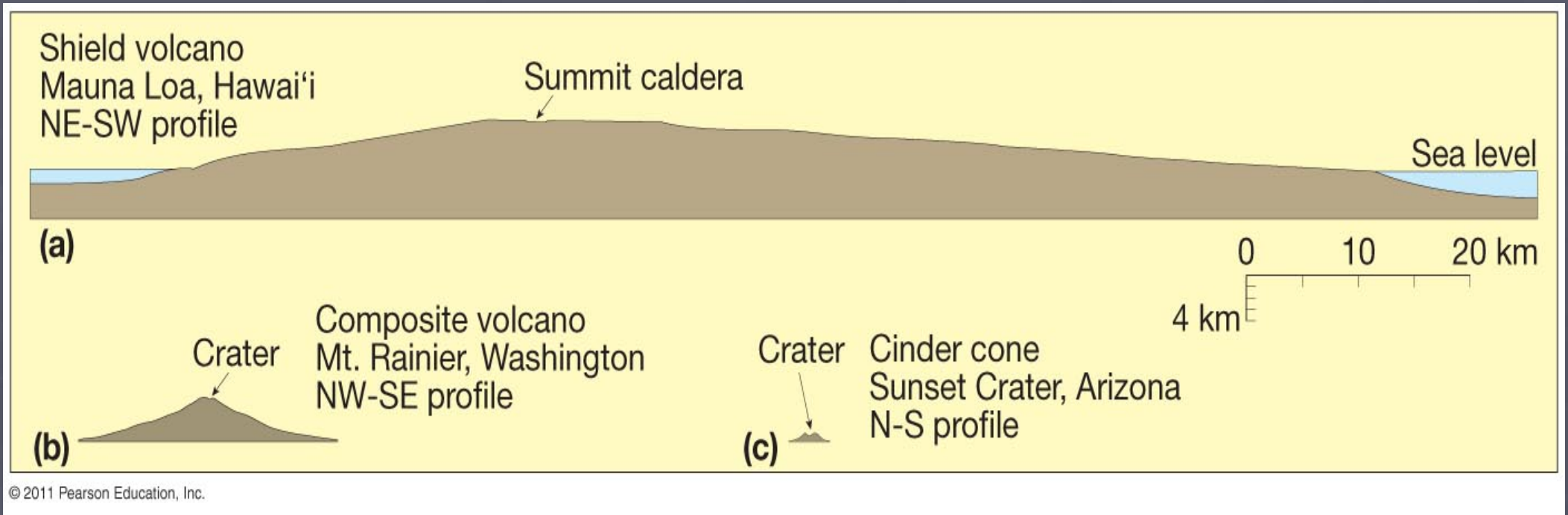
Caldera volcano

Anatomy of a Volcano - Terminology



Types of Volcanoes - Shield

- Usually very large, broad/slightly domes
- Primarily made of basaltic (fluid) lava



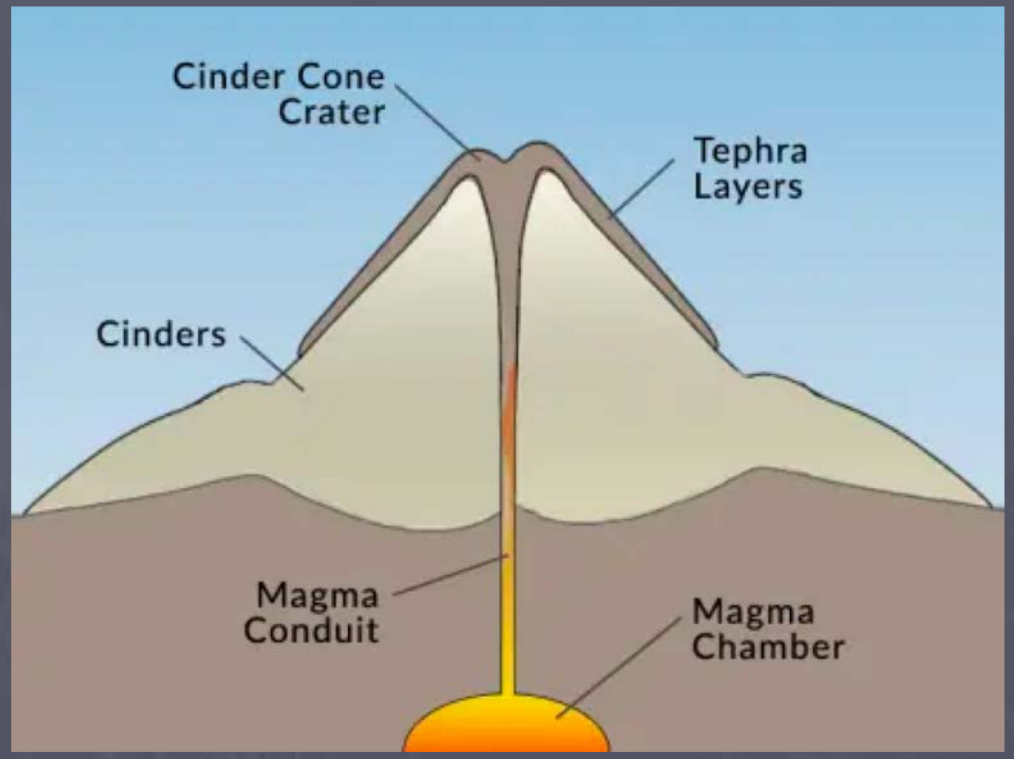
Santiago – Galapagos Islands

Fernandina – Galapagos, Ecuador

2018 Eruption

Types of Volcanoes – Cinder Cone

- Single vented volcanoes that are built up over time by expelled lava



Sunset Crater in Arizona

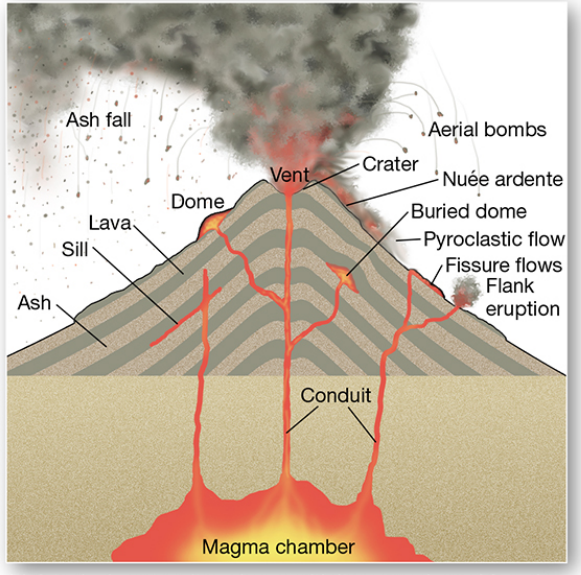
Volcanic Landscapes - Caldera

- Calderas are built from the collapsed summit at the top of a volcano

Krafla Volcano’s Caldera (Northern Iceland

Types of Volcanoes – Composite (aka Stratovolcano)

- Can be most explosive of eruptions
  - Conic shape – sometimes bulges as pressure increases
  - Can produce a Pyroclastic Flow
    - Mixtures of chemicals and ash that can travel at speeds upwards of 125mph
  - Lahar – Floods of pyroclastic materials, water, and debris that accompany eruptions



(a) A typical composite volcano with its cone-shaped form in an explosive eruption.

(b) Mount Redoubt, Alaska, erupts in 2009.

Lahar

Mount Saint Helena
1982

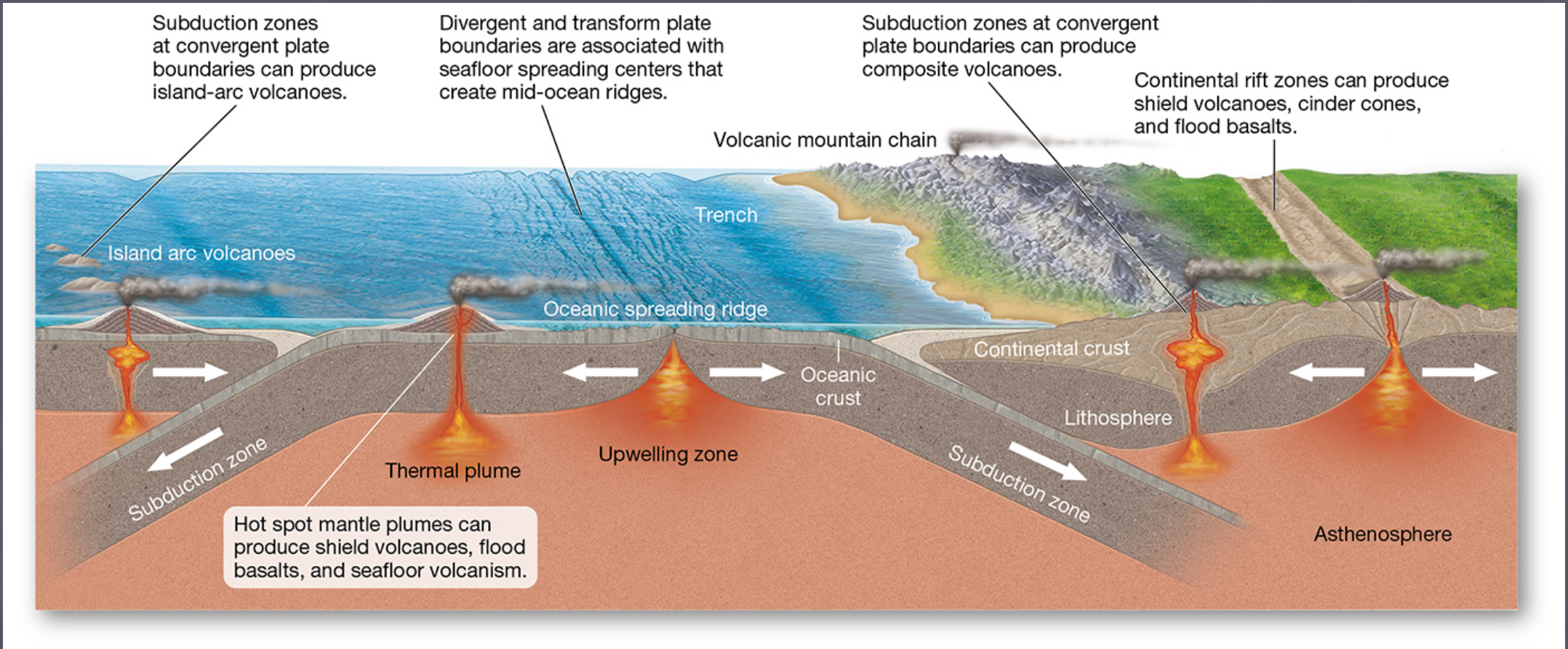
Pyroclastic Flow

- Pyroclastic Materials
  - Ash and dust – fine, glassy materials
  - Pumice – Rocks formed from frothy lava
  - Blocks – Hardened lava
  - Bombs – Hot lava that has been ejected

Mount Saint Helens 1980

Volcanic Activity

- Takes places along faults or weak spots on Tectonic Plates



Worldwide Volcanic Activity

- Roughly 50-60 volcanos erupt per year globally
  - Japan, Mexico, the Philippines, Indonesia, and Iceland are global hotspots
  - 2-3 per year in the United States (Mostly Alaska)

2021 Eruption of Fagradalsfjall in Southwest Iceland

Volcanic Eruptions

- Dependent upon three factors
  - Composition of the magma
  - Temperature of the magma
  - Dissolved gases in the magma
- Volatiles (dissolved gases) provide force to extrude lava
  - Gases more easily escape from fluid magma
  - Viscous magma traps in gasses and creates more violent eruptions

Eruptions

Sinabung Volcano in Indonesia

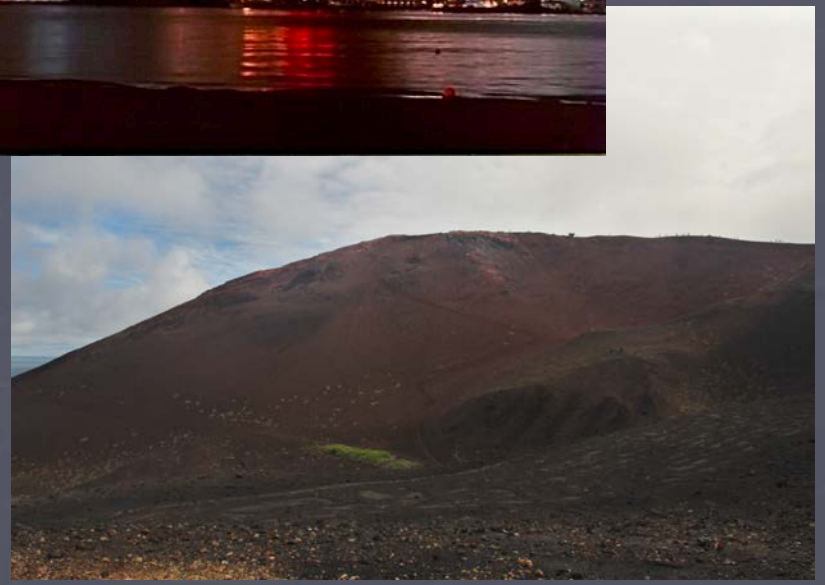
Pu‘u ‘Ō‘ō on Kilauea, Hawaii

Lava/Magma Flows

- Three Factors Affect Viscosity of Lava
  - Composition (silica content)
    - High Silica – high viscosity
    - Low silica – more fluid
  - Temperature
    - Hotter magmas are less viscous
  - Dissolved gasses (Volatiles)
    - Water vapor and carbon dioxide mostly
    - Gases expand near the surface

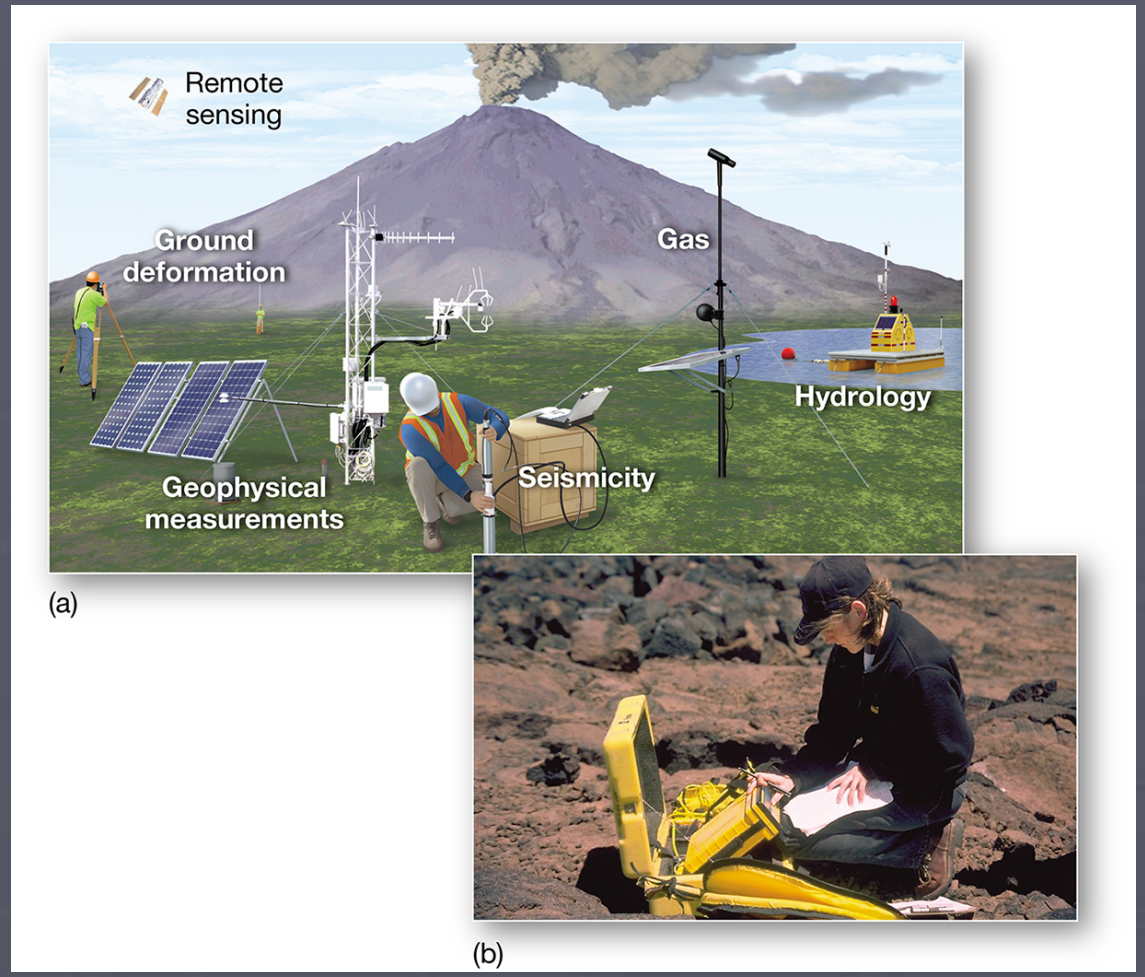
Volcanic Landscapes - Lava Flows (Reykjanes Peninsula)

Eldfell Eruption 1973

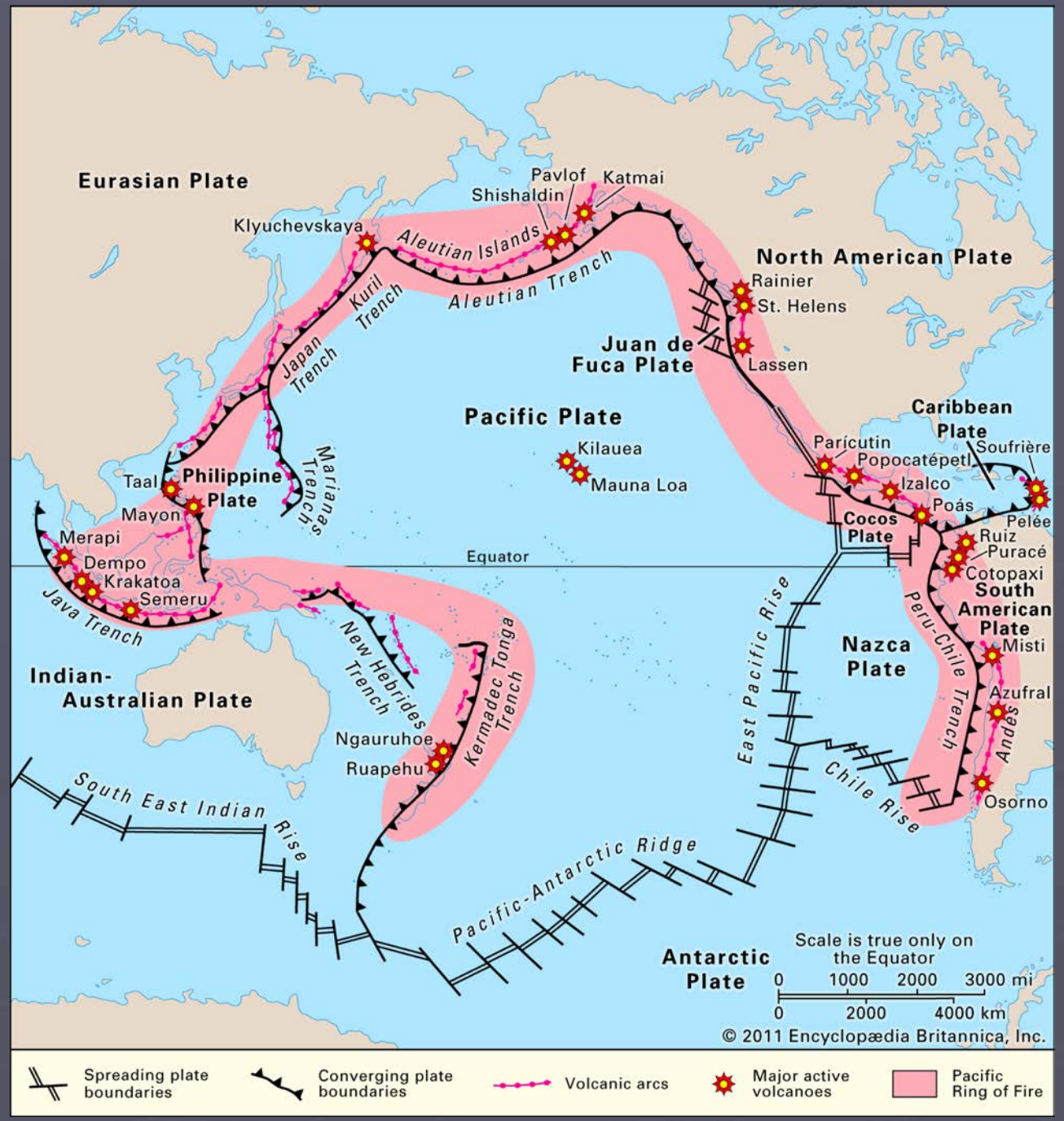


Volcanic Monitoring

- Sensors monitor volcanic activity to predict eruptions
  - Also make predictions based on how frequently volcano erupts
- Classifications
  - Extinct – no longer able to erupt
  - Dormant – minimal danger or erupting but still possible
  - Active – Presently erupting or due to



Pacific Ring of Fire



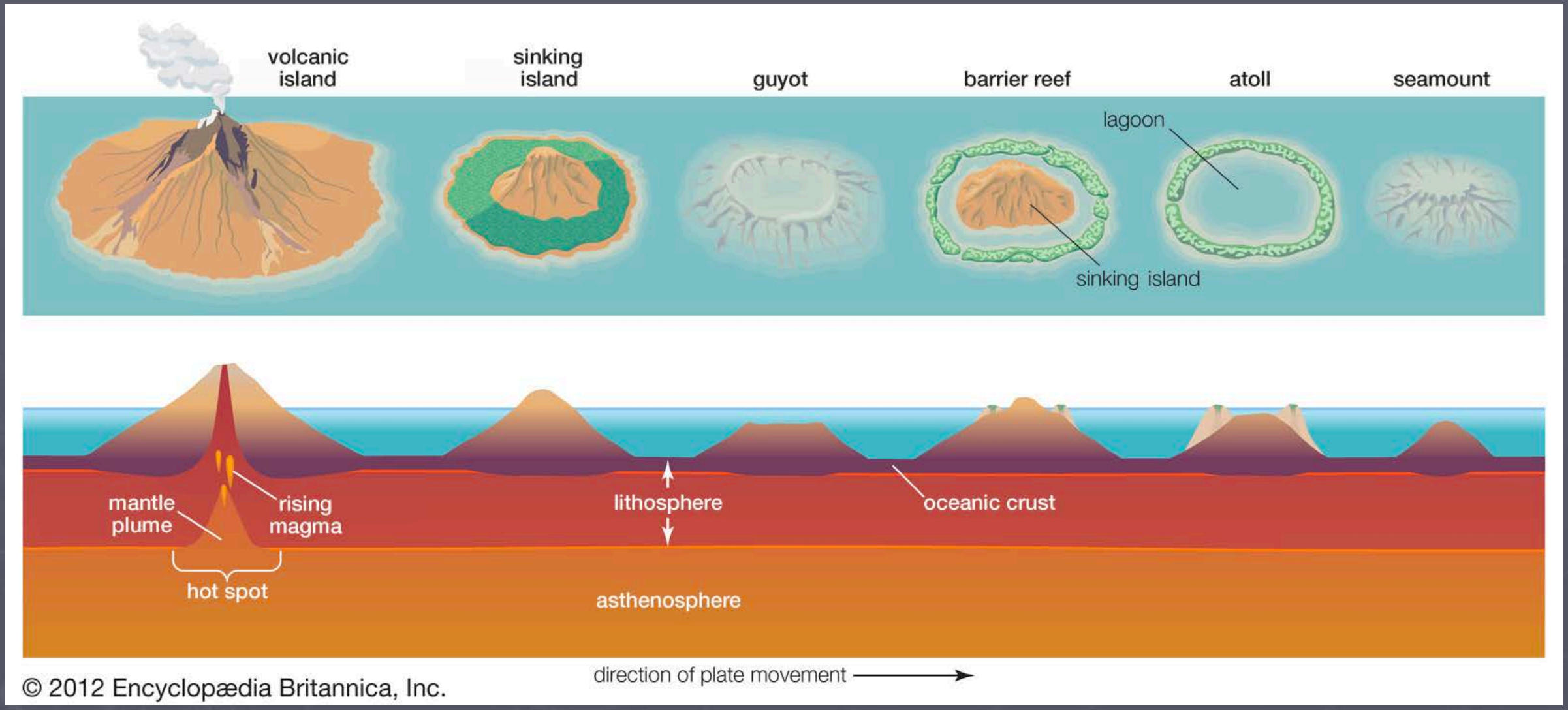
Volcanic Landscapes - Basalt Columns

Vik, Iceland

Giant’s Causeway, Northern Ireland

Volcanic Landscapes - Hot Springs and Geysers

Formation of Volcanic Islands



Ecuador Volcano – Galapagos, Ecuador

Alcedo, Darwin, and Ecuador on Galapagos, Ecuador

Island Laboratories – Surtsey, Iceland